

Pathways for Introduction and Early Detection of Aquatic Species

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Pathways of Introduction



- Zebra mussels cost \$100s million per year in U.S. to remove from water pipes, screens, intakes
- Aquatic plants (*Hydrilla*, *Egeria*, Water Hyacinth) and seaweed invasions (*Caulerpa* in So. CA) cost CA \$\$ millions per year
- In CA, Chinese mitten crabs, European green crabs and other have also resulted in substantial costs
- Many pathways for non-native invasive aquatic plants and animals to enter California
- Likely thousands of species come in but few survive

Pathways of Introduction



- Discharged in ships' ballast water
- Attached to fishing gear, anchors, lines
- Attached to ships' hulls

Underwater view of a highly fouled ship hull showing attached fouling organisms



Pathways of Introduction

- Release from home aquariums
- Escape of live seafood products
- Dumping of live bait containers and packing materials



Pathways of Introduction



- Transfers of aquaculture products or fish stocks
- Intentional introductions to establish new fisheries
- Escape from backyard ornamental ponds



Ballast Water

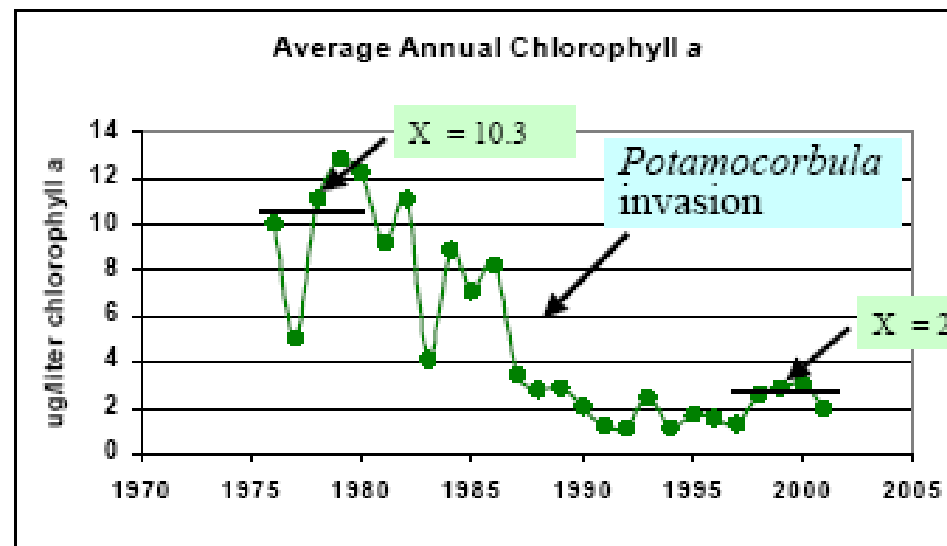


- The most well-known pathway
- More than 2 million gallons of ballast water are dumped in U.S. harbors every hour
- Up to three hundred species have been identified in ballast of single ship
- Uncertainty about viability of organisms
- High quantity but low quality

Ballast Water



- **Asian Clam *Potamocorbula amurensis***
 - Can reach abundances of 25,000/sq m in SF Bay
 - Filter the volume of the bay in shallow areas 3 x/day
 - Has eliminated seasonal cycle of planktonic plants that support the SF Bay foodweb



Hull Fouling

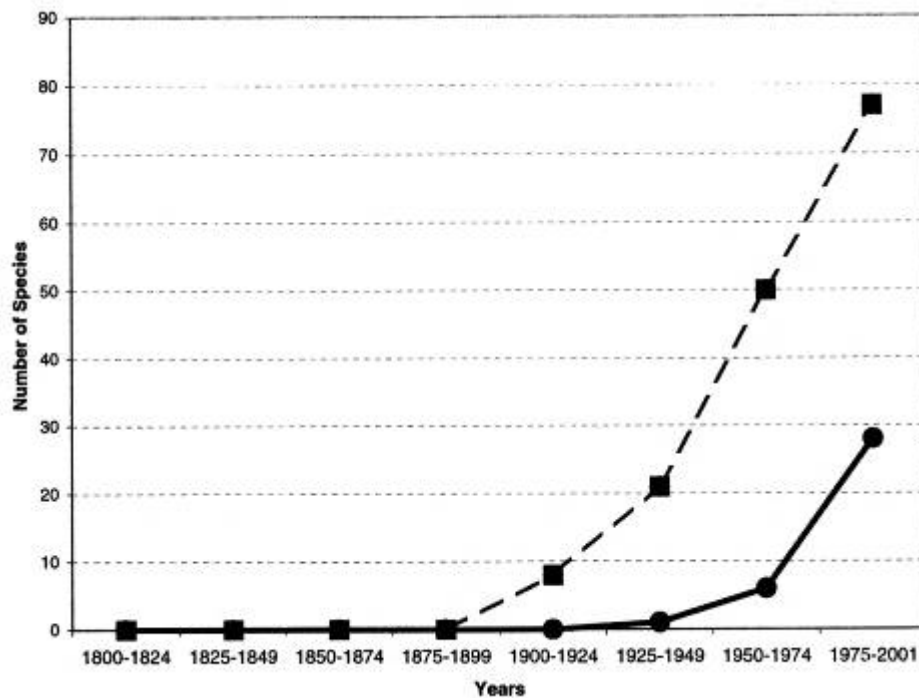
- Attached species & others organisms living in/on others are transported among harbors
- Transports reproductive adult organisms
- More important than ballast water?



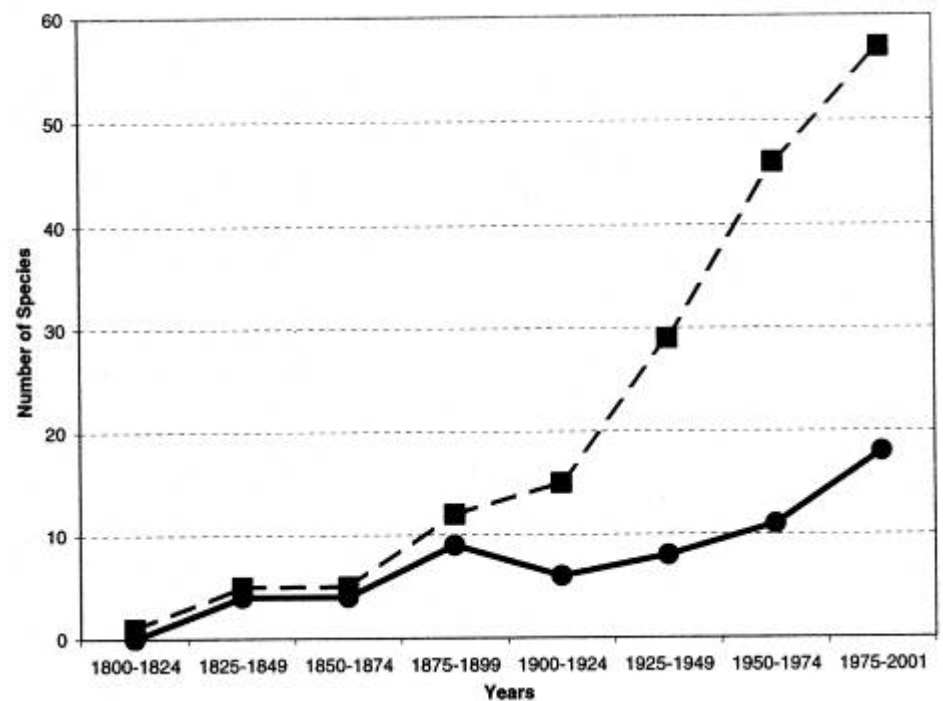
Underwater view of a highly fouled ship hull showing attached fouling organisms

Hull Fouling

Ballast as sole or possible vector



Hulls as sole or possible vector



From: Fofonoff, Ruiz, Steves & Carlton. 2003

Aquarium Introductions



- Many non-native species of fish, invertebrates and algae sold in U.S.
- In CA, there are 900 non-native species of fish for sale in aquarium stores
- A small number (10-15) could become established in San Francisco Bay
- Pets commonly “released” when get too big or aggressive
- Many species could potentially become established

Aquarium Introductions

- The invasive alga *Caulerpa taxifolia* (Med.) had huge impacts in Mediterranean where no control measures used
- In CA in 2001, cost more than \$4 million over four years for eradication San Diego and Orange Cos.
- Officially declared eradicated Feb. 2006



Live Seafood



- Many species of non-native fish and invertebrates (oysters, mussels, clams) are sold on live seafood market
- Potential for release during storage or after sale

Live Seafood

- Chinese Mitten Crab (*Eriochier sinensis*)
- New England seaweed *Ascophyllum nodosum* (packing material)



Live Seafood



- Mitten Crabs live in freshwater as juveniles then return to Bay to reproduce
- Chinese Mitten Crabs clogged Fish Salvage Facility in 1998
- Nearly shut down the facility which would have stopped Tracy pumping facility

Live Bait

- **Non-native species of fishes and many species of invertebrates are sold live as bait**
- **Bait boxes (worms) also contain up to two dozen species**
- **Poorly regulated, little inspection capacity**

Live Bait

- European green crab (*Carcinus maenas*)
- Large impacts on coastal ecosystems
- Impacted local shellfish stocks



Live Bait



Seven foot long
“Nuclear Worm”
(*Namalycastis* sp.)

Backyard Ponds



- Fastest growing segment of horticulture industry
- 16 million backyard ponds
- Little regulation regarding placement near waterways or storm security



Backyard Ponds

- Cost CA millions \$\$ every year to control
- *Hydrilla*
- Water hyacinth (*Eichhornia crassipes*)
- *Egeria densa*
- Eurasian watermilfoil (*Myriophyllum spicatum*)



Boats and Trailers



- **Recreational boats and trailers are frequently and rapidly transported over significant distances**
- **Little regulation regarding cleaning boats, trailers, other exposed equipment**

Boats and Trailers

- **Very likely possibility of zebra mussels invading California**
- **Several instances of live zebra mussels found on boats entering CA**
- **A matter of time...**



Early Detection

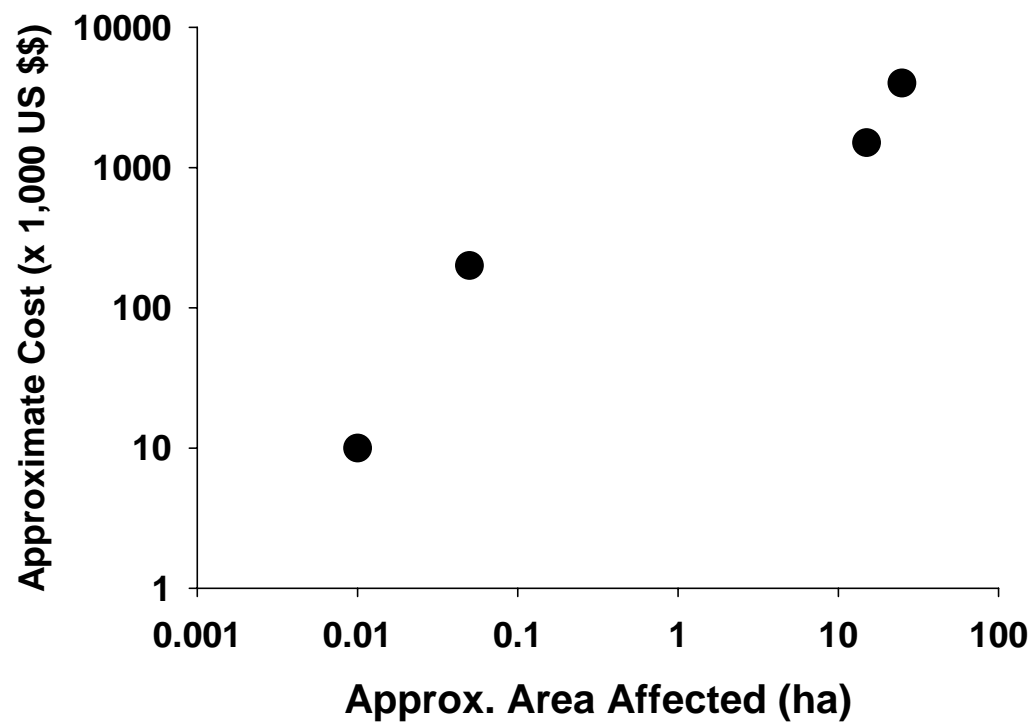
- **Most cost-effective investment is fund a regular survey of high priority sites of introduction**
- **Early detection of an invasion can allow eradication just after the species has become established**
- **An annual survey of 6 high priority sites in CA could be accomplished for a few hundred thousand \$\$**

Successful Eradication

Four examples of successful eradication in coastal systems

Species	Site	Cost	Area Treated (ha)
Black Striped Mussel	Australia (NT)	\$1.5 million	15
Caulerpa	California (SD, OR)	\$4 million	25
Abalone parasite	California (MB)	\$200,000	0.05
NE seaweed	California (SF)	\$10,000	0.01

Eradication Costs



Rapid Response Planning

- **Eradication is only possible as the result of early detection and a very rapid response**
- **A comprehensive rapid response plan for priority species is required for effectively dealing with a new invasion**
- **Prior agreements/MOUs outlining authorities and means of coordination must be in place before the invasion**
- **Public education to raise awareness about the the risks and costs of invasions**
- **A comprehensive statewide plan is the solution**

Rapid Response Planning

- Expect the unexpected
- CA was not listed as a potential site for *Caulerpa*
- Plan for Zebra mussels, what about Golden mussels (spreading in southern Brazil, Uruguay) with same potential impact



Golden Mussels in
Brazil *Limnoperna
fortunei*

Rapid Response Funding

- Rapid action to eradicate a new invasion will require immediate access to unrestricted funds
- The *Caulerpa* success underscores how important the availability of resources is for an effective and comprehensive response
- \$10 million should be set aside (*untouched*) for rapid response efforts to AQUATIC INVASIONS (\$ 1 million per year for 5 yrs x 2 invasions per ten years)

Cost of Inaction

- Mitten crabs signaled how susceptible the water distribution system is to invasions
- Zebra mussels (golden mussels?) have the potential to seriously impact the water distribution system in CA
- Delta supplies irrigation water for multi-billion \$\$ California agriculture and drinking water for 22 million people
- What do we tell them if the water distribution system is compromised?